A WAY AROUND THE VOLCANIC ASH CLOUD

Volcanic ash simulations show ways out of the crisis
By Angela Schmitt

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In the cockpit, the pilots cross the last items off their checklist. No thunderstorms have been forecast for today – but a volcanic ash cloud from Iceland is making its way across the sky. Will the flight have to be postponed or cancelled on short notice? Can the ash cloud be circled, or is it expanding in the opposite direction? Will the destination airport be ash-free upon arrival? Will the air traffic controllers give clearance for landing at all?
The DLR project 'Volcanic ash impact on the Air Transport System' (VolcATS) examines the issue of volcanic ash, its effects on air traffic and possible solutions to these problems. The ash spewed into the air during a volcanic eruption heavily restricts the surrounding air space that is usable for air traffic. The free air space must then be used efficiently to minimise the negative impacts on both the airlines and the passengers. DLR researchers in Braunschweig have used different simulations to identify the reasons for flight cancellations or delays due to volcanic ash and have developed action strategies for better handling problems encountered as a result of ash clouds. The aim is to carry out as many flights as possible and to assist in making the best decision possible about whether or not flights should be conducted.

The VOLCATS PROJECT
In VolcATS (Volcanic ash impact on the Air Tranport System), six DLR Institutes investigate the impact of volcanic ash on air traffic. The project will last until September 2016. The simulated volcanic ash data was made available by the DLR Institute of Atmosperic Physics. The Institute of Flight Guidance analyses strategies to minimize the impacts on air traffic.

Flying in the event of a volcanic eruption
The general rule is that flying through clouds of visible ash is prohibited. After a volcanic eruption, a central agency gathers all data relevant to air traffic. This information is processed for the pilots, the airlines and the responsible air traffic services so that all parties involved can make a well-founded decision. If flying is considered to be possible, the pilot will still have the final say: this is the person who is most aware of the local situation and ultimately decides whether the flight will or will not take place. For this crisis program to work, efficient communication between all players involved is of utmost importance.
The crisis scenario simulated by the researchers is based on the recorded ash cloud caused by the eruption of the Icelandic Eyjafjallajökull volcano in April 2010 (see also satellite image below *). Based on this data, two different scenarios were created – one simulates the worst case in

which great quantities of ash are spread widely, and the other shows the more optimistic case in which the ash cloud is predicted to only be present at lower altitudes and over smaller areas.

To play out these scenarios, the Braunschweig researchers extended the area covered by the Airport and Control Center Simulator ACCES. All of the flights scheduled on the day in which flying was heavily restricted due to the ash cloud were fed into the realistically replicated control centre. They computed the flight paths of the originally scheduled flights, and were thus able to examine whether the strategies developed in the meantime would really have resulted in more flights occurring on that day. Approximately 5000 flights took place on the day observed – had air traffic been ‘normal’, there would have been 22,000 flights. A newly developed module – the Trajectory Optimizer – searches for efficient trajectories to circumnavigate the ash clouds. In the control center, a central projection screen shows the graphically processed trajectories.

The Trajectory Optimizer determines the shortest or fastest ash-free routes; these may differ depending on wind conditions. Based on an airline’s policy, it may then decide which trajectory is to be flown. Subsequently, the experts analyze whether the decisions made would have had positive or negative effects on the total number of possible flights.

Two different airspace structures were examined in the VolcATS project; first, the currently used structure in which the airspace is divided into smaller areas, known as sectors. There are two air traffic controllers for each sector, who guide the aircraft safely and efficiently through their sector. The associated problem is that alternative flight routes can result in too many aircraft travelling through the same sectors in the vicinity of ash clouds, thus overloading these areas. Therefore, a cross-sectoral structure was also analyzed in the simulated ash scenario. In this variant, what comes into play is not the individual sectors, but rather one single air traffic controller guiding specific flights – from take-off through to landing. The evaluation of this procedure determines whether or not the sectors are overloaded – if so, detours through other sectors are necessary, which may lead to delays.

Different strategies to the test

A scenario: the ash cloud forecast is announced in the planning stage. The experts determine that a scheduled flight can no longer take place.

Computing an ash-free trajectory is possible, but it conflicts with another flight. The crisis committee of the control center simulator enables the affected airlines to discuss their plans and decide on the specific flights, keeping the lines of communication short. The ultimate decision is then fed into the airline information system via a specially developed program. The updated flight schedule is then accepted by the air traffic management and updated in the overall situation overview.

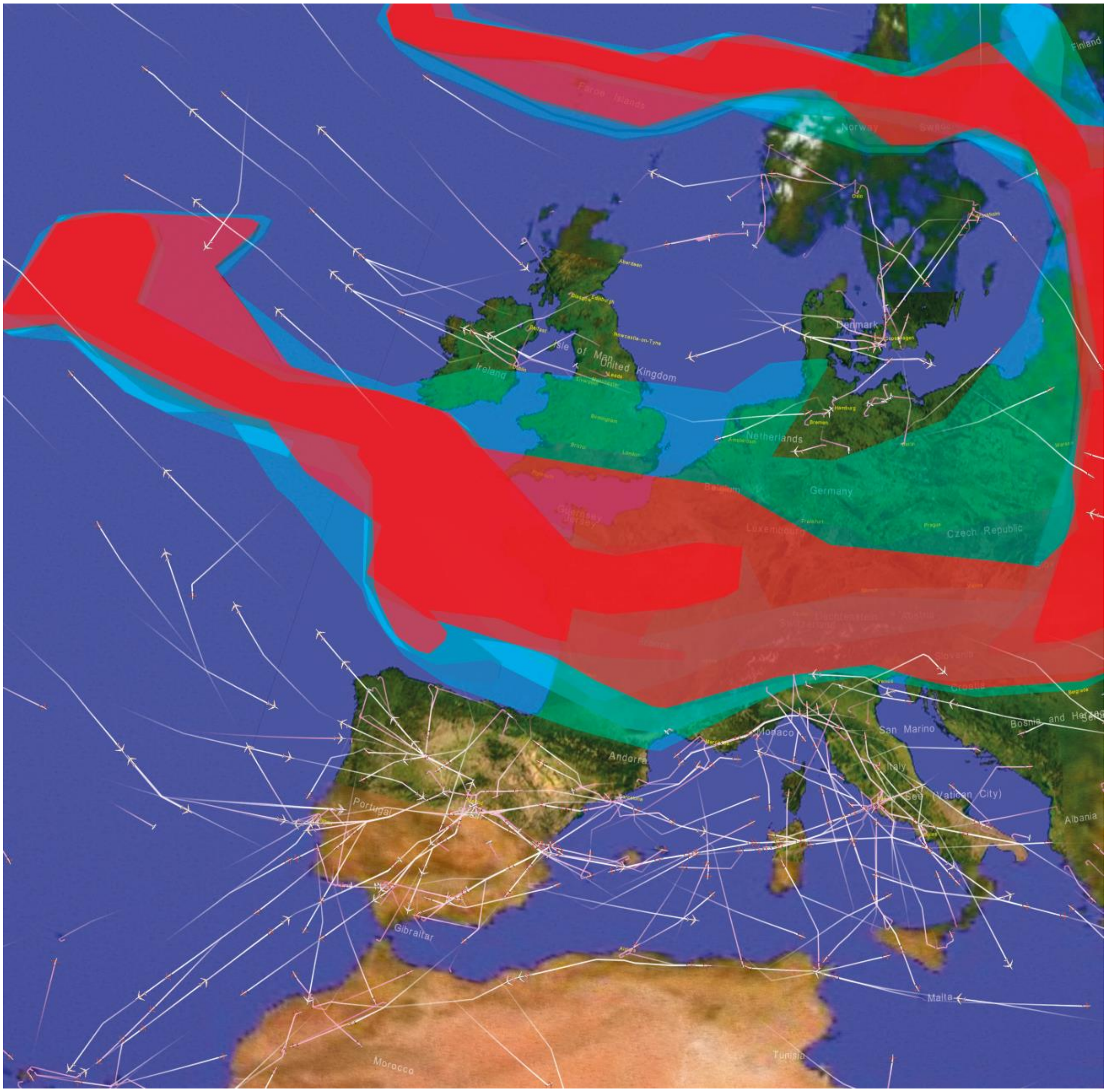
One result of the simulated crisis – the progress achieved in the forecast of ash clouds in recent years leaves more room for planning. Information on the spreading of ash clouds is updated every six hours – similar to weather information. This means that an up-to-date information package is available every six hours. The information package includes the status of the last six hours: the actual status (T+0), and forecasts in six-hour steps for the next 18 hours (T+6, T+12 and T+18). The six-hour forecasts show the range of motion of the ash particles. The bigger the ash clouds, the less airspace remains available for air traffic.

The improved ash forecasts make it possible to limit no-fly areas with greater precision. This increases the number of areas cleared for air traffic, and more flights can be carried out.

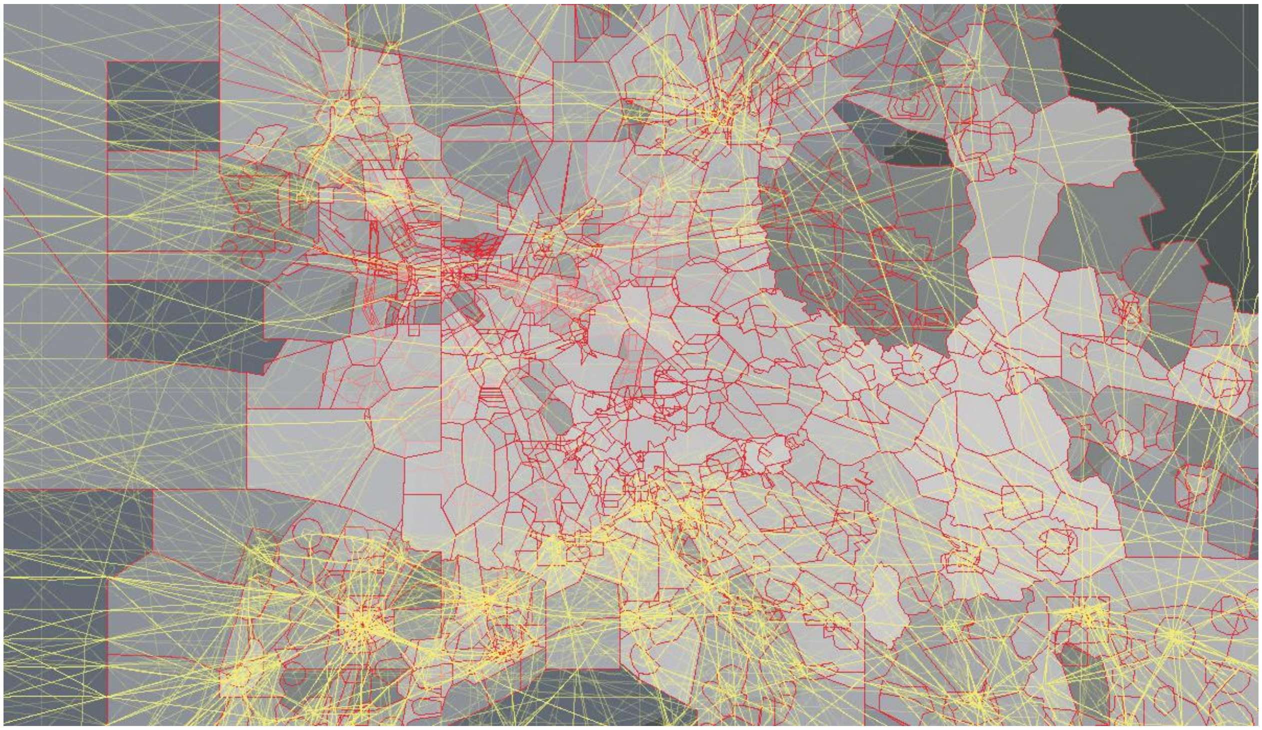
In addition, the extended simulation environment showed that the main cause of cancelled flights is the ash load at the airports. The ash spewed into the air by the volcano naturally decreases over time – like a pyramid, it covers a larger area on the ground and decreases with increasing altitude.

Even with six-hour forecasts, the large area on the ground remains blocked for the entire period of time. Only about 20 percent of cancelled flights are due to problems with ash clouds in flight. The scientists are, therefore, testing different options in the simulations to further decrease the number of flight cancellations caused by the impairment of airports.

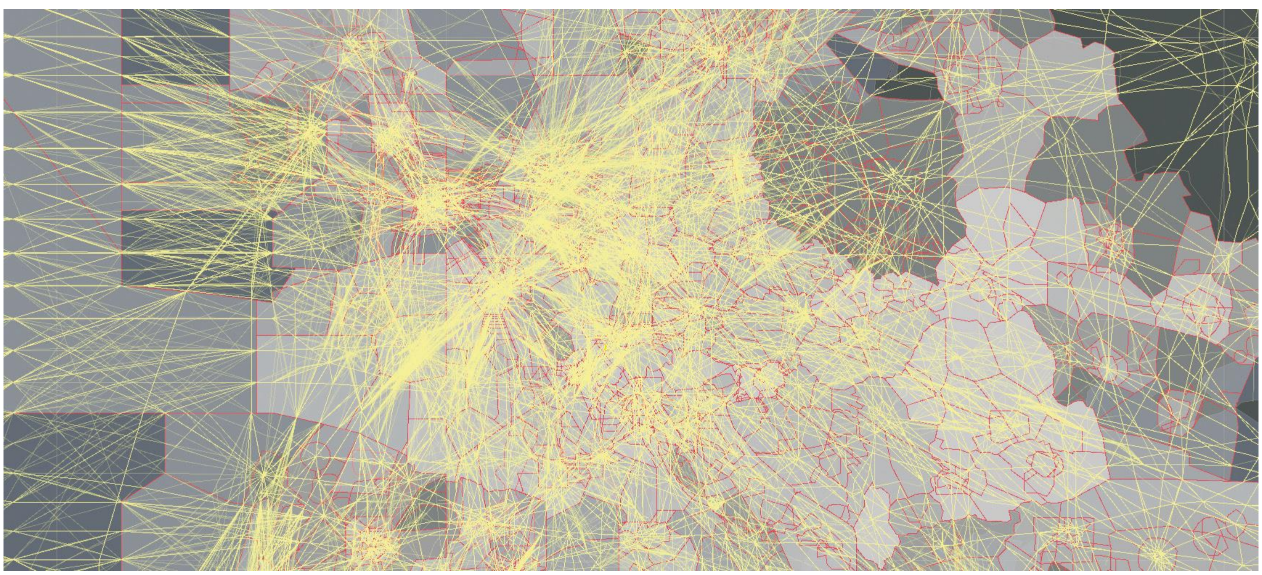
One research question, for example, is: can the number of cancellations at the airport be reduced if the departure time is postponed several hours?
The simulations of both ash forecast scenarios showed that 30 to 70 percent of the normal traffic volume is affected by the ash clouds. Even in the worst ash-volume case, approximately 1900 more flights could take place with the improved forecast alone. An additional 1500 flights are possible by planning alternative routes – a result that offers hope that extreme situations – such as that caused by the Eyjafjallajökull eruption six years ago – do not repeat themselves.



Simulation of air traffic over Europe in the event of predicted volcanic ash clouds (red and light blue zones; DLR Software: FATS)



The same day – above with ash, and below without ash. Avoidance air traffic (yellow) and existing sector structure (red) together reveal congested sectors. Flying is also possible over the predicted ash zones. Software: AirTOp, air traffic based on EUROCONTROL DDR data (below).



Simulation of ash crisis in the control room simulator ACCESS at DLR Braunschweig. On the big screen, the overall situation is always visible.

*) Satellite image of the real Eyjafjallajökull ash cloud

By May 26, 2010, when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured this photo-like image, Iceland's Eyjafjallajökull Volcano had slowed its eruption. A tiny, white puff of steam rises from the volcano in this image. Considerable steam had been coming from the crater, said the Icelandic Met Office, but monitoring the eruption became difficult because of windblown ash. The problem is illustrated here. Two broad swaths of tan ash, many kilometers across, obscure the Icelandic coastline and sweep over the Atlantic Ocean.

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June 2016, formatted by Joachim J. Kehr, Editor SpaceOps News of the "Journal of SpaceOperations & Communicator" (http://opsjournal.org)